Note for Readers' Forum for

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THE KUTTA CONDITION AND THE CONDITION FOR MINIMUM DRAG

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In a recent communication Yoshihara and Strand[1] conclude that the conditions for minimum drag in lifting surface theory are not valid for wings with singular edge forces. Such edge forces are normally incorporated in the surface integral for drag by a limiting process. In the communication referred to, however, the edge forces are given a separate expression in the form of a line integral taken around the edge. The line integral is then added to the expression for the direct drag, but is omitted in the expression of the interference drag (i.e., in the Ursell-Ward relation). This inconsistency evidently leads to the erroneous conclusion.

The selection of a distribution of lift by the condition of minimum drag does not, in general, agree with the selection imposed by the Kutta condition. The latter condition merely selects a flow as being physically probable in a viscous fluid.

With plan forms pointed at the front or rear the optimum distributions of lift do, in fact, require suction peaks at either the leading or trailing edges. Thus, in the case of a slender triangular wing moving base foremost such a peak appears along the trailing edge and a component of the minimum drag appears as a downstream edge force. Fig. 1 illustrates

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two methods by which this singular mathematical model might be interpreted in a practical sense. (In actual practice boundary-layer control might be employed.) Clearly, our consideration of the sharp edge and the limiting process is only an effort to simplify the formulas. If the limiting calculation produced a result different from that obtained by integrating the nearby smooth pressure distributions, then we would find it difficult to attribute any physical significance to the result.

It is interesting to note that the optimum distribution of lift over the reversed triangular wing is not given by the writer's slender wing theory, since the latter theory is concerned with the magnitude of the lift as determined by the Kutta condition. For the optimum lift distribution we have to return to Munk's original airship theory.

REFERENCE

1. Yoshihara, Hideo, and Strand, Torstein: On Jones' Criterion for Optimum Lifting Wings. Jour. Aero/Space Sci., vol. 25, no. 9, Sept. 1958, p. 600.

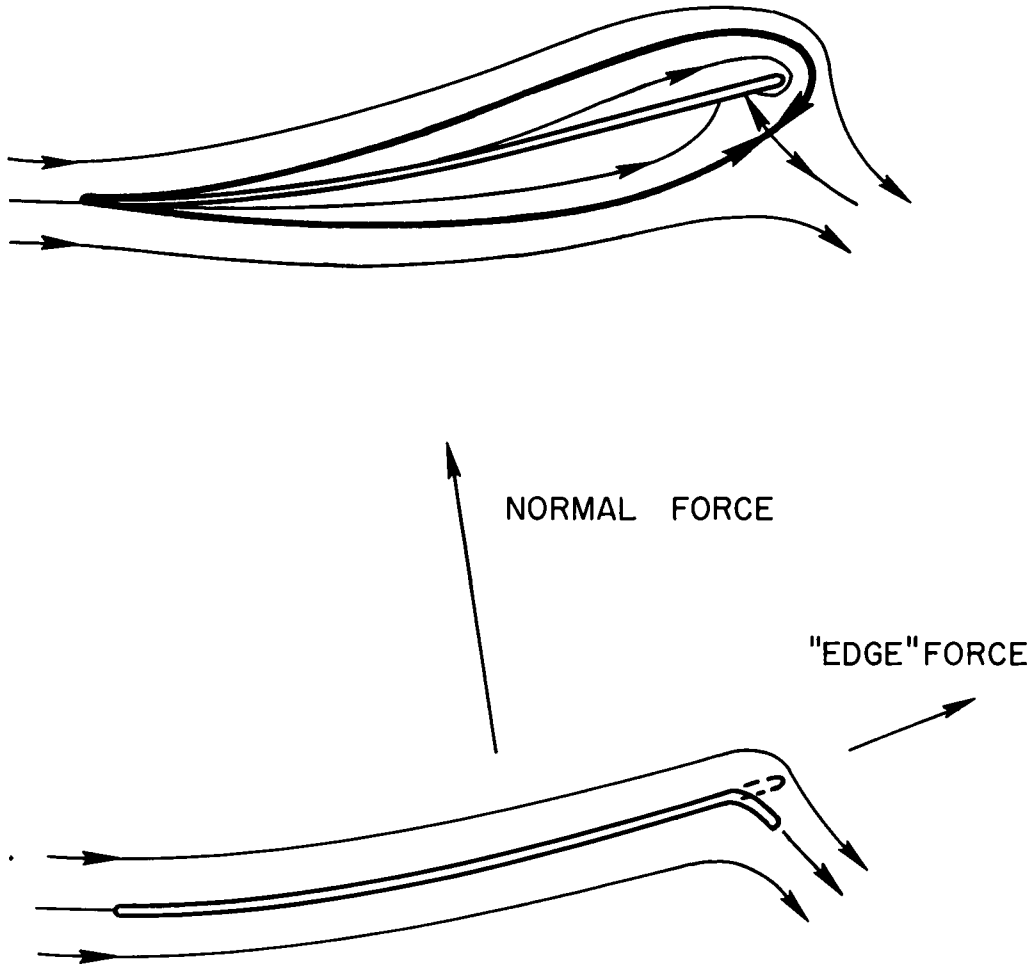

Figure 1. - Alternative interpretations of a trailing-edge singularity.